APPARATUS GRAPHICALLY REGISTERING

MOTIONS OF RAIL-ROAD TRAINS

AND

SYSTEM OF SIGNALS

FOR PREVENTING COLLISIONS;

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The system I propose, to avoid collisions between trains, offers on the *block-system*, now in use in England and France, the advantage of giving greater security and a more economical working; it can also give a greater capacity to the tracks without danger.

It particularly well adapts itself to the working system now applied in America, because it gives at every moment to the *train-despatcher* the position of all the trains on the same track, and enables him, in case of danger, to give a warning signal to the engineer of the moving train.

GENERAL DESCRIPTION OF THE SYSTEM.

The moving train automatically traces its graphic by points formed on a band of paper, slowly unrolling under the eyes of an employee placed in a stationary signal post. This agent has in sight the movements of all the trains on a section of 50 or 100 miles, or more if necessary, the signal-post occupying the middle of the section or thereabout; so he can see if two trains are moving towards one another on the same track, or if two trains are following one another, whether the second tends to overtake the first one.

The signal-post agent, by starting the steamwhistle on the locomotive itself, can give a slackening signal to the engineer of one of the trains and renew it if necessary. At this alarm, the engine-driver must so master the speed of his engine as to be able to stop in the

64269

portion of the track in sight, which he must attentively survey. The engineer will take up his normal speed again after having travelled through a fixed distance (1 mile for instance), from the point he received the last signal.

So long as a train on the main-track remains in a station, a continuous line is traced on the graphic; this avoids one of the most frequent causes of accident (accident of Charenton, accident of Saint-Mandé).

So as to compel the signal-post agent, having to survey on the graphic the trains's movements, to be constantly attentive, and, so as to have a control of his vigilance, this employee must also, by means of an electric ring or bell, inform each station of the arrival of a train when it is at a fixed distance from the station (2 miles for instance). This signal, already in use on several railroads, offers, as it is well known, a great advantage : it enables to open the road to an incoming train before the driver can see the disc; so the latter, usually finding the road opened before him, pays a much greater attention to a stop or slackening signal.

The whole system is based on the use of electric communications, the good working of which can easily and continually be controlled. As will be seen later by the description, the recepting apparatus, giving the trains's graphic, has no delicate mechanism likely to get out of order, it is most simple.

The transmitting apparatus placed in the signal-post are very simple commutators; they actuate the relays laid in closed boxes along the road or in the stations. The transmitters on the track consist : 1° in contact apparatus, similar in working to the *crocodiles* of Lartigue's system, but offering on them the advantage of being able to work in all weathers, even with glazed-frost or frozen snow; 2° in treadles of a new and robust system capable also of working in all sorts of weather.

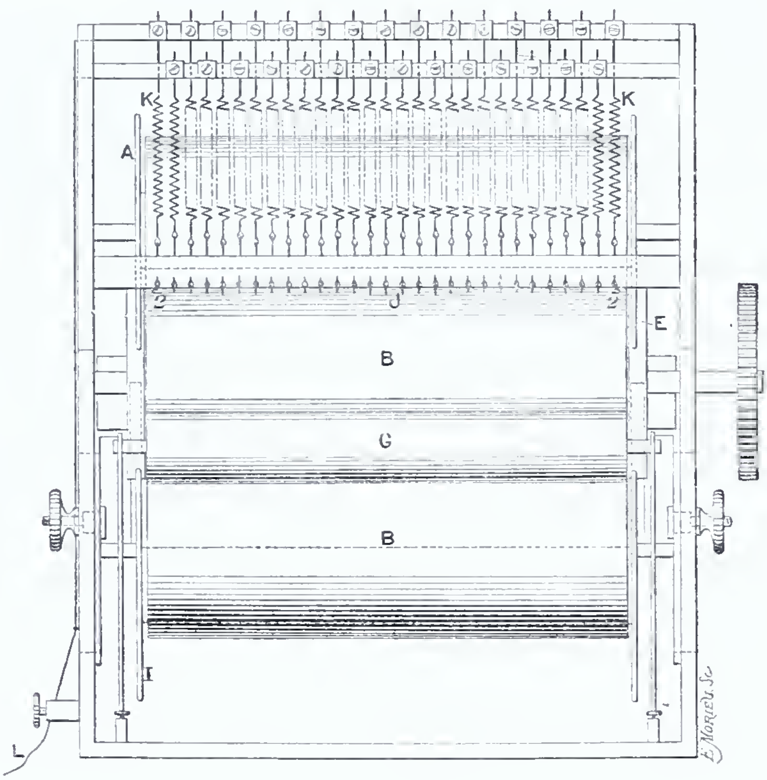
1° Registering apparatus (*fig.* 1 and 2). — The apparatus, tracing by means of points the trains's graphic, is based upon the electro-chemical decomposition of a weak dissolution of iodide of potassium [1] (at $\frac{1}{150\text{th}}$), impregnating a band of slightly feculent unsized

(1) It is a well known that iodide of potassium is quite an inoffensive substance; its

paper, as is found in the trade. This impregnation is automatically operated by the apparatus itself.

This apparatus consists of a nickelled brass cylinder E, slowly and uniformly revolving by means of a clock-work mechanism. The sheet

Fig. 1.



of paper BB passes on the surface of this cylinder and advances with it at the rate of about $\frac{2}{10^{th}}$ of an inch per minute. A row of steel pins (henceforth called needles), of about the size of a knitting needle, terminating in platinum points JJ, are placed above the paper and press upon its surface by means of springs K, which also serve to establish the electric communication. Each of these communicate by a special conductor (wires L) with a treadle placed on the track; these treadles are equidistant ($\frac{1}{2}$ mile from one another for instance). Cylinder E is permanently connected to the negative pole of battery P (*fig.* 3), the positive pole of which communicates with a return conductor K, common to all the treadles.

When a train passes on a treadle Q, the circuit of battery P is

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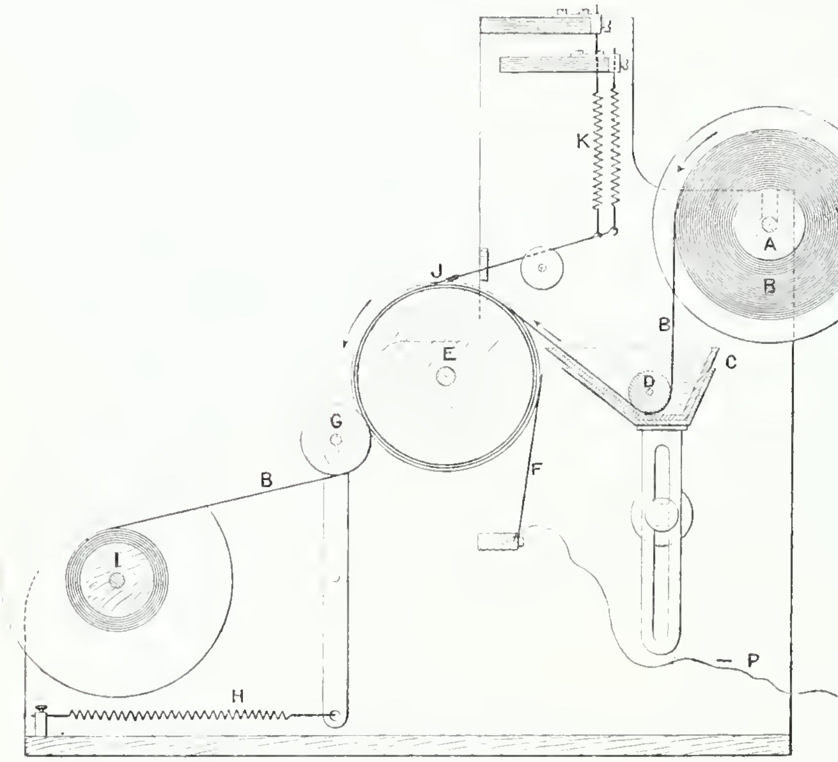
weak dissolutions can be indefinitively kept without any alteration. The expense for paper and iodide is insignificant (30 cents per week and per apparatus).

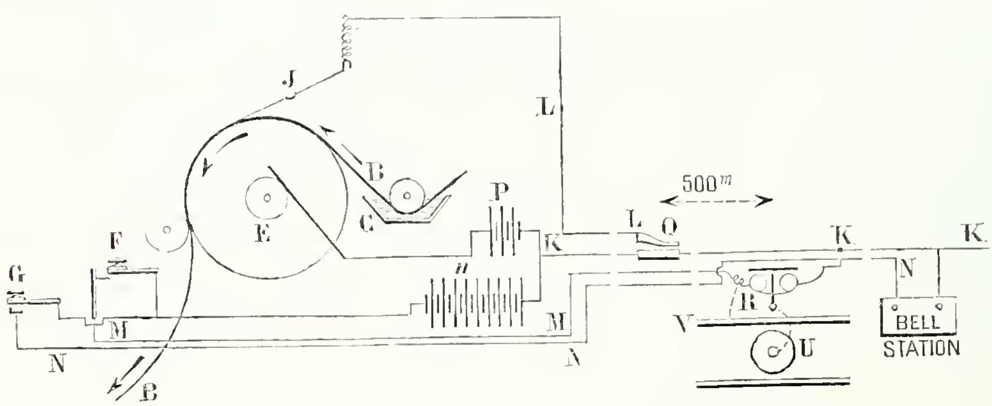
momentarily closed and a very visible black point, due to liberation of the iodine, is formed on the paper under the platinum point cor-

Fig. 2.



responding to the treadle; this black point informs the train despatcher in the signal-post that the train is passing on the corresponding treadle.

Fig. 3.



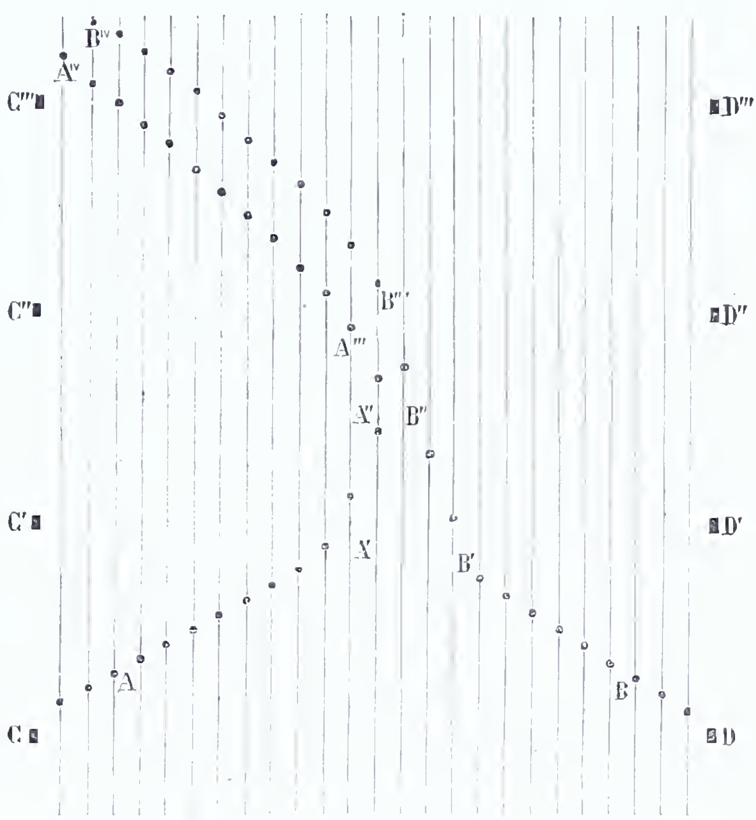
A small battery of very few elements (3 Leclanché elements or 4 Callaud elements, for instance), placed in the signal-post, is sufficient for all the treadles, and for distances reaching over 1000 miles, much more than is wanted here.

The black points, formed by the passing of a train on each treadle, constitute by their ensemble the train's graphic (*fig.* 4).

From what we have just said, it can now be understood that there is a needle for each treadle, 80 for each apparatus for instance (there is only 25 shown on *fig.* 1).

Every 10 minutes, the clock-work mechanism, actuating cylinder E, closes a battery circuit during a very short laps of time, and causes a horizontal black line to be formed on each edge of the paper in front the row of platinum points; these lines CC′C″C‴ and DD′D″D‴ (*fig.* 4) serve to calculate the time on the graphic.

Fig. 4.



FAC SIMILE OF A GRAPHIC OF TWO TRAINS IN SAME WAY.

Legend. — The trains A and B are going to meet each other; in A′ and B′ is given the signal for slackening the speed; in A″ and B″ they arrive slowly in view of each other and stop. Train A retrogrades (A‴ A^{IV}) while train B follows at a suitable distance (B‴ B^{IV}).

Every hour the signal-post agent must mark the time on the paper in front the line formed, and every day at noon the date. The train's

number must also be written on the side of each graphic. These bands of paper form very useful documents for detecting irregularities in the service, and, as such, can be kept by the control-service.

Fig. 1 and 2 will enable to fully understand the registering apparatus. With larger dimensions than those shown on the figure, the magasine-drum A can hold enough paper for two or three months working.

We must add that each needle is distinguished from the next ones by a special number and color; a series of seven or eight colors, periodically reproduced, is sufficient. The same color, white for instance, will be attributed to needles corresponding to station treadles, they will also carry the number of the corresponding station.

Generally there will be two of these apparatus in each signal-post, one for the up-track, and one for the down-track.

2° Treadle (*fig.* 5). — The treadle adopted is of a very robust form and its contact organs being protected by a double casing, good working is secured in all sorts of weather.

The projecting rim of the locomotive's wheel, or of any other car, when passing on a treadle, presses on its top part, made of a piece of flat steel MM, carried by spring OO, and brings it dow at least $\frac{3}{8\text{ht}}$ of an inch. Steel pieces TT forming body with bar MM and, moving in slots VV, guide the whole system in its movement. Projecting hobs YY prevent bar MM from going down lower than a certain point slightly below the level of the rail against which it is placed.

The lowering of the treadle brings one, or preferably two brass cylinders *cc* in contact with brass piece *g* and causes electric communication between the conductor L, special to this treadle, and conductor K common to all the treadles. Cylinders *cc* can move without friction inside of brass tubes so as to follow the down ward motion of the treadle, always greater them the distance of $\frac{2}{25\text{th}}$ of an inch existing, in state of rest, between contacts *cc* and piece *g*. The contact surfaces are platinated, or, better still, are terminated by elastic brass blades, so as to obtain a friction securing a perfect contact.

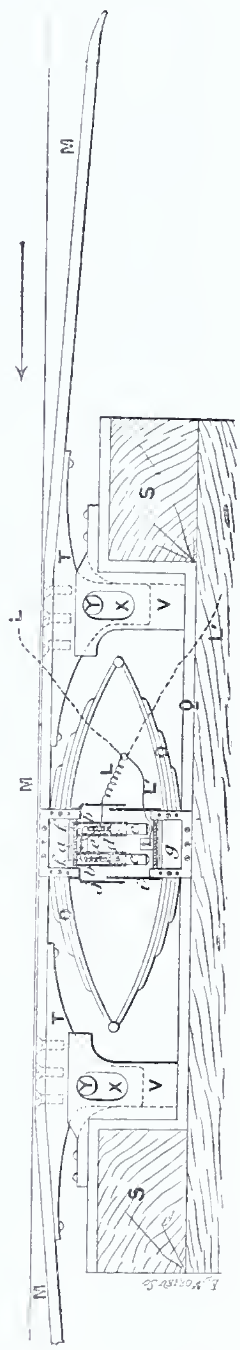
A kind of galvanized painted box *i* and cover *j* protects the contact organs. An analogous disposition casing the whole of the treadle,

excepting bar MM, guarantee sliding organs against stones, rain or snow.

Bar MM extends at both ends in form of an inclined plane.

It is clear that the dispositions and details of the treadle, shown in the figure, can be so modified as to be able to place this apparatus on the cross-sleepers of the track without having to modify the latter in any manner whatever. The single spring can be replaced by two or more vertical springs, placed either parallelly or perpendicularly to the tracks, if the sleepers are too near one another. Balance weights, similar to those of the levers actuating change of track switches, can also be substituted to the springs.

Fig. 5.



A counter-rail, placed in front the treadle, prevents any running off the rails in the very improbable case that, owing to an accident to a treadle and not withstanding the enormous weight of the engine, the top part of the treadle should not have been lowered.

In depots and stations, a long treadle will be placed in front the wainting-rooms, where the cars are stopped when the train is on the main-track. This treadle long enough to have two wheels resting on it, even in case of a long sleeping car, is constituted by a series of treadles, of the some type as the one already described, having a single bar MMM. The object of this is to close the circuit during all the time the train is stopped and consequently to obtain on the graphic a line, the length of which indicates how long the stoppage lasted. This indication, as we have already explained, has especially in view to prevent a collision in a depot; but, as can easily be seen, it is also useful for the control service.

The same treadle, without having its organs modified, can close,

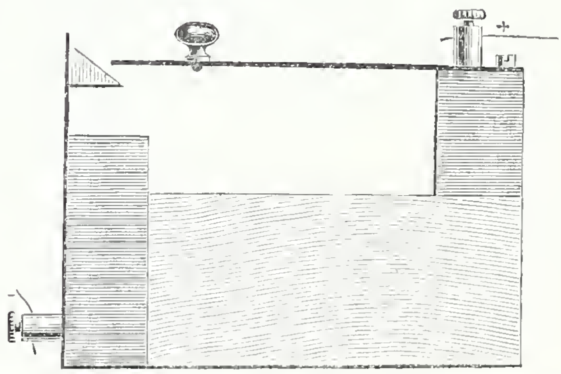
at the same moment, the circuits of two different signal-posts; this is useful in some cases ([1]).

The treadles carry the numbers of the corresponding needles of the registering apparatus.

As an inscription can be made by a current passing through a very great resistance (500000 ohms for instance), the conductors L, connecting each treadle with its corresponding needle, have no other limit to their fineness than the one resulting from the necessity of giving them a sufficient thickness, so as not to break.

3° Commutators and signals on the locomotive. — In front of each of the signals-post registering apparatus are placed, in the same manner as the keys of a piano, as many (or very nearly) gearing-commutators [*fig.* 6 (and F *fig.* 3)] as there are treadles. These can

Fig. 6.



put in communication an especial conductor (wires M) with the positive pole of a battery *n*, the current coming back by the same return conductor K used for the treadles's current.

The current of this battery *n* then actuates a relay R placed in closed box along the track; this relay puts an insulated contact apparatus U in communication with the rail V; so that, when the locomotive passes above the contact apparatus, a metallic brush will momentarilly close the circuit of a battery formed of one or two closed cells and placed upon the locomotive. The current resulting from this

([1]) It is easily understood that, without in any way modifying the rest of the system, any other good system of treadle can be adopted, for instance Siemens and Halske's mercury treadle.

will throw out of gear the armature of a Hughes electro-magnet and put in operation a special steam-whistle placed on the engine's boiler; at the same moment the white disc in front the eyes of the engineer will be replaced by a red one. The steam-whistling can only stop when the engineer puts back in gear the electro-magnet armature. This is the signal the engineer must obey, as before explained.

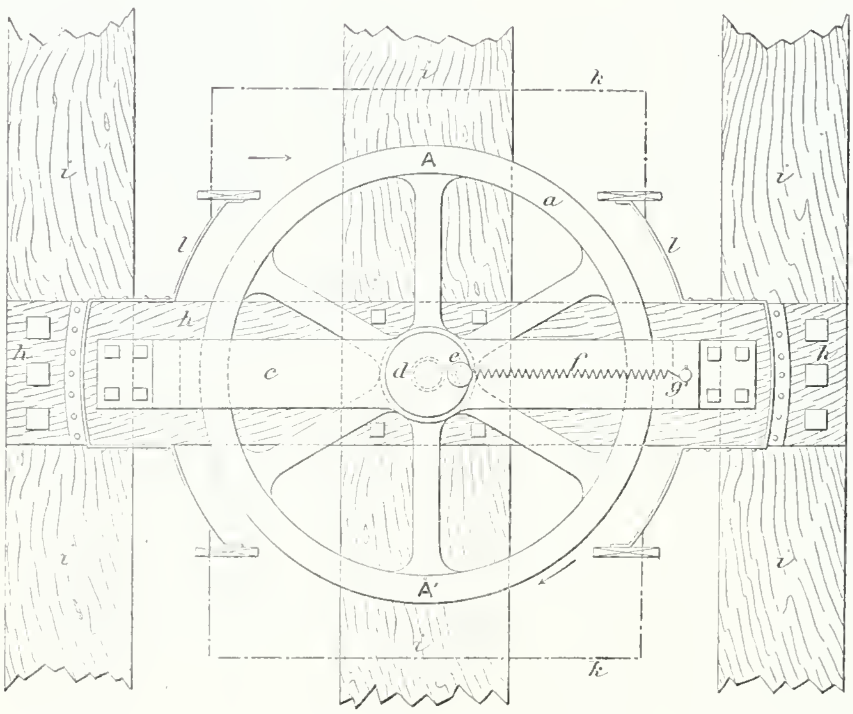
The contact apparatus are generally placed half-way between the treadles (at 440 yards from each treadle when these are $\frac{1}{2}$ a mile apart). The commutator, corresponding to a contact apparatus, carries the two colors and numbers of the needles corresponding to the treadles between which the contact apparatus is placed. So if the train-despatcher considers necessary to slacken the speed of a train, the key of the commutator he must put in gear is shown to him without ambiguity and in the clearest manner. He must also, for sake of prudence, gear in the two following commutators in the direction of the train's motion in case, however rare it may be, that, by some accident to a contact apparatus, the alarm should not have been produced, and also in case the engineer, by negligence, should not have obeyed the first signal. The signal-post employee knows that the engineer has received and obeyed the signal by the graphic itself, which shows that the speed of the train has been reduced. If he then considers that there is no inconvenience to allow the train to resume its normal speed, he can release the commutators he geared in by prudence, before the train reaches the corresponding contact apparatus (1).

4° Contact apparatus (*fig.* 7). — The contact apparatus, placed in the middle between the rails, consists of a cast-iron drum covered

(1) Without modifying the registering apparatus and by means of a very simple modification of the commutators, it might be possible, if the board of control found it useful to register on the graphic the moment when the train-despatcher geared the commutator, when he released it, and what commutator it was. This would be shown by two black points, simultaneously appearing under the two needles corresponding to the two treadles situated on each side of the contact apparatus actuated by the commutator. This sign (. .), formed when the commutator is put in gear, and when it is released can not be mistaken with the points giving the train's graphic. The graphic would thus prove that the employee gave the signal at the required moment. (The *fig.* 6 of the commutators and the schema refer to a disposition in which this improvement does not exist.)

with brass, 32 inches diameter and 7 inches wide, supported by a vertical steel spindle *d*; this spindle revolves in steel bearings carried by a cast-iron frame *cc*. This frame is insulated by means of an imputrescible tarred wood foundation *hh*, attached to the sleepers carrying the track *i*, *i*, *i*. The whole apparatus is protected against snow or rain by a painted and galvanized skeet-iron box *ll*. At the two extremities of the same diameter AA′, perpendicularly to the rail, the drum protrudes from 3 inches to 4 inches outside the

Fig. 7.



box; this external part A or A′ is swept by a metallic brush with horizontal staples attached to the locomotive. The length of this brush (about 100 inches) is equal to about the periphery of the drum; by passing over this drum, it causes it to turn and bring in contact with the metallic staples the part of the drum usually remaining inside the box, so that it might be protected against glazed-frost. The contact takes place, in all kinds of weather between the metallic brush and the drum, consequently between the metallic brush and the rail when the relay works. (The contact misses with Lartigue's crocodile in time of glazed-frost.) The brush, insulated from the metallic mass of the locomotive, communicates with one

extremity of the Hughes electro-magnet conductor actuating the steam-whistle; the other extremity being fastened to one pole of the battery, the second pole of which is connected by the metallic mass of the locomotive to the rail. A spring *f*, acting on a crank *e* carried by the rotating drumspindle, brings back the drum, after the passage of the engine, in the same position as before, so that all the parts of the drum may not be successively covered with glazed-frost.

Besides, sheet-iron covers *kk* protect, in a large measure, the external portions of the drum against rain and consequently against glazed-frost.

This system, besides being able to work in any weather, has another advantage on the crocodile system: the wear and tear of the brush is greatly reduced, because a rolling friction is substituted to a slipping one.

The application of the above described contact apparatus may be rendered impossible in certain cases in America, when the sweeper of the locomotive is placed only at a short distance above the track. In such cases this contact apparatus will be replaced by any other suitable contrivance. For instance the contact apparatus may be formed of a vertical drum, rotating upon a horizontal shaft placed across the track and between the rails; the greater part of this drum may be protected against rain and glazed-frost by a casing from which the drum will project so that its upper part be placed slightly above the level of the rails. In this case the metallic brush placed on the engine will have vertical bristles which will make contact with the upper part of the drum and cause it to rotate. A counterweight will always place at the bottom of the casing the same part of the drum as soon as the train is passed.

5° **Warnings to depots and stations.** — A system of ordinary commutators G (*fig.* 3) consisting in as many apparatus as there are depots, stations and bifurcations in a section, enables to put the positive pole of battery *n* in communication with a special conductor N, connecting to the relay-rest of an electric-bell in a depot, station or bifurcation-post; the other relay-rest communicating with the return conductor K. The circuit of the battery and relay being closed, the latter causes the current of a local battery to pass in an

apparatus producing an audible signal, completed by an optic one, if thought necessary. This signal can be given by Leopoder bells, usually employed in France; so the signal-post agent can give the number of strokes, indicating the arrival of a train on the up or down track in the normal direction, or in the reverse one.

Let us suppose that the warning signal must be given when the train is at a distance of two miles from the station; it is advisable to give one same color, red for instance, to the needles of the registering apparatus corresponding to the treadles situated about two miles before the stations, in the normal direction of the trains. Things being so, as soon as the signal-post employee sees a black point appearing under the red needle, he knows that he must press his finger upon the commutator bearing the number of the corresponding station; this number being marked in front the white needle, near the red one; this white needle, we repeat it, corresponds to the long treadle of the station itself. However to prevent any mistake, each commutator is placed on a table in front the corresponding white needle.

In the same manner, to signal a train moving in the reverse direction, the needles corresponding to the treadles placed two miles above the stations in the normal moving direction, are painted with the same color, black for instance.

6° Length and dispositions of sections. — Each section under control of one signal-post might have a distance from 100 to 200 miles, without requiring very powerful batteries; but as one agent cannot at the same time survey a great number of trains; considering also that the cost, on account of the multiplicity of conductors, augments rapidly with the length of the section, it is generally preferable to give them at a shorter distance. The length of each section and the distance of the treadles from one-another depend upon the number of trains running. The rule is that the section must give the minimum kilometre-expenditure for working expenses and first cost; sections, having the length, calculated further on this rule, contain, at a maximum, 4 or 5 trains at the same time on french lines. As the train-despatcher must rather frequently examine the graphic, so as to signal to the stations at the necessary moment, without encur-

ring fatigue or over-exertion of the mind, the above quantity will be found quite proper.

In double-track signal-posts there must be two employees, at least in France, one for each track; but, as during a short time, one employee can survey two apparatus without any risks of making mistakes in the signals sent, the transmitters being grouped round the receiving apparatus, the other agent can take some moment's rest, or proceed to some slight repairs. However as the signal-post can always be placed in an important station, the agent of a one track post can always, if necessary, call up an inferior employee to momentarily replace or help him.

Consecutive sections must overlap one another so that three or four treadles may be common to both sections.

Bifurcations require special conditions, but they are easy to realize.

Line wires. — All the line wires may be placed together in an underground cable protected by a lead cover or sheath $\frac{1}{10\text{th}}$ of an inch thick, so that the whole of the cable and envelope is about as big as the finger; the lead cover is used for the return wire K. The relays may also be placed in underground lead boxes, hermetically sealed and contained in cemented chambers. By these means, the perfect insulation of the conductors is obtained and moreover accidents in the whole circuit and expenses for the maintenance of the same are completely avoided.

8° Control of the apparatus's good working. — Non working cases. — We will only say here that a simple control, which can frequently be made, shows when an apparatus is going to miss, before any danger can occur in the working of the system (wear of brushes, weakening of batteries, etc.). We will also say that all interruptions in the signal service, on account of an accident to a treadle or contact-apparatus, etc., are immediately known, and that in the Memoir submitted to the examination of the *Comité d'exploitation technique des chemins de fer*, of France, measures are indicated to rapidly obviate them so that no accident can occur to the moving trains.

9° Economical part. — The multiplicity of conductors will certainly be objected to; but this multiplicity offers no other incon-

venience than the annual interest on first cost of plant. Now it is easy to see that this sum does not sensibly exceed the salaries paid to signal-post agents, and that, every-thing taken into account, this system is much more economical than the block system; if the cost of conductors is greater than in the latter system, this is greatly compensated by a diminution in the number of employees, because the sections, instead of being from 2 to 2 $\frac{1}{2}$ miles long, are in this system from 50 to 60 miles.

It is interesting to research what is the length of section giving the minimum expense. This length depends on the distance between the treadles, which itself is determined by the rapidity with which trains follow one another, or, in other words, upon the capacity to be given to the road in normal working.

Taking in consideration the interest at 3 $\frac{1}{2}$ per cent on the amount expended for first cost, wages of employees (3 employees at 1800 francs each per signal-post for each track), etc., we find that the annual expense per kilometre for one track is approximatively given by the following formula

$$p = \frac{5937 + 570d}{x} + 88{,}66 + \frac{37{,}80}{d} + \frac{1{,}25}{d}\, x,$$

calling d the distance between two consecutive treadles and x the total length of one section, these two distances expressed in kilometres; p expressed in francs.

The value X of x which gives the minimum expense is obtained by

$$X = \sqrt{\frac{(5937 + 570d)d}{1{,}25}}$$

what give the following Table :

Distance between treadles d.	Length of most economical section X.	Annual expenses per kilometer p.	Capacity of roads.
km 0,5	km 50	fr 414	Very loaded as road from Paris to Creil.
1,0	72	307	Loaded as road from Paris to Lyons by Burgundy.
1,5	90	264	Less loaded lines.

The wages alone of the employees required with the block system is nearly double the yearly expenditures of the proposed system. On

the Paris to Creil road, for instance, with the block system the sections are 2^{km} long; consequently two employees (one day, one night) for 2^{km} and two tracks, admitting a salary of 1400 francs par annum for each of them, it can be seen that the annual expenditure is 700 francs per kilometer and track, instead of 414 francs.

SECURITY GIVEN BY THE SYSTEM.

I wish particularly to insists on the security this system offers, as it was to diminish the chances of accidents that it was imagined.

I know of no accidents the block system can prevent, which cannot also be avoided by the proposed system, while some exist against which the block system has no action and which cannot occur with my system.

For instance, the last accident at La Chapelle was due to the inattention of the block system agent, who fancied the train was out of the section while it had stopped upon it; by unduly opening the section on such a loaded line he necessarily caused an accident. No accident of this kind can happen with our system, because at every instant the signal post agent sees the respective positions of the trains, his memory does not come in action.

The lack of visibility of the signals for rapid train drivers, or the non observation of these signals, has caused many accidents; the terrible catastrophe of Saint-Mandé for instance. In the system offered, the repetition of a prolonged signal on the locomotive compels the engineer to obey, even if he is asleep or in a state of semi-intoxication; it is a permanent signal for the employees of the train, and especially for the engineer, as it only stops when he puts in gear the armature of the Hughes electro-magnet; he can only miss to obey by a nearly criminal ill-will.

When by inadvertance, on a one track block system road, two trains have been sent towards one another from station to station, there is no means of avoiding an accident, even when the mistake is perceived (Monaco accident). An accident of this kind is not to be feared with the proposed system.

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